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Produced by the NASA Center for Aerospace Information (CASI)

Report No. 78-066
Contract No. NAS8-~~30031~~ 32490

NASA-CR-150745

(NASA-CR-150745) INTERACTIVE SIGNAL ANALYSIS AND ULTRASONIC DATA COLLECTION SYSTEM USER'S MANUAL Final Report (M and S Computing, Inc., Huntsville, Ala.) 40 p HC A03/MF A01 CSCL 09B G3/61

N78-28831

Unclas 25921

Preliminary

FINAL REPORT

INTERACTIVE SIGNAL ANALYSIS AND ULTRASONIC DATA COLLECTION SYSTEM USER'S MANUAL

Preliminary

June 6, 1978

Prepared for:

George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama 35812

M&S COMPUTING, INC.

PREFACE

The Interactive Signal Analysis and Ultrasonic Data Collection System (ECHO1) User's Manual provides a detailed description for using ECHO1 to collect and process data received from Pulse-Echo ultrasonic systems. ECHO1 was developed for NASA at Marshall Space Flight Center (Contract No. NAS8-32490) to collect and process Ultrasonic Signal Data for NASA analysts.

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Preliminary

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1. INTRODUCTION

The Interactive Signal Analysis and Ultrasonic Data Collection System (ECHO1) is a real-time data acquisition and display system developed by M&S Computing, Inc., Huntsville, Alabama, for the National Aeronautics and Space Administration (NASA) Non-Destructive Testing Laboratory located at the George C. Marshall Space Flight Center in Huntsville, Alabama, under Contract NAS8-32490.

ECH01 software is supported by the hardware configuration shown in Figure 1-1. ECHO1 executes on a Digital Equipment Corporation (DEC) PDP-11/45 computer under the RT11 real-time operating system. Extensive operator interaction provides the requisite parameters to the data collection, calculation, and data display modules.

Data is acquired in real-time from a pulse-echo ultrasonic system using a Biomation Model 8100 Transient Recorder. The data consists of 2084 intensity values representing the amplitude of pulses transmitted and received by the ultrasonic unit.

Calculations are performed on the real-time data using the Elsytec MFFT-11 Hardware Array Arithmetic Processor and Fast Fourier Transform (FFT) software.

Data display provides near real-time plots of all collected and calculated data.

HARDWARE CONFIGURATION

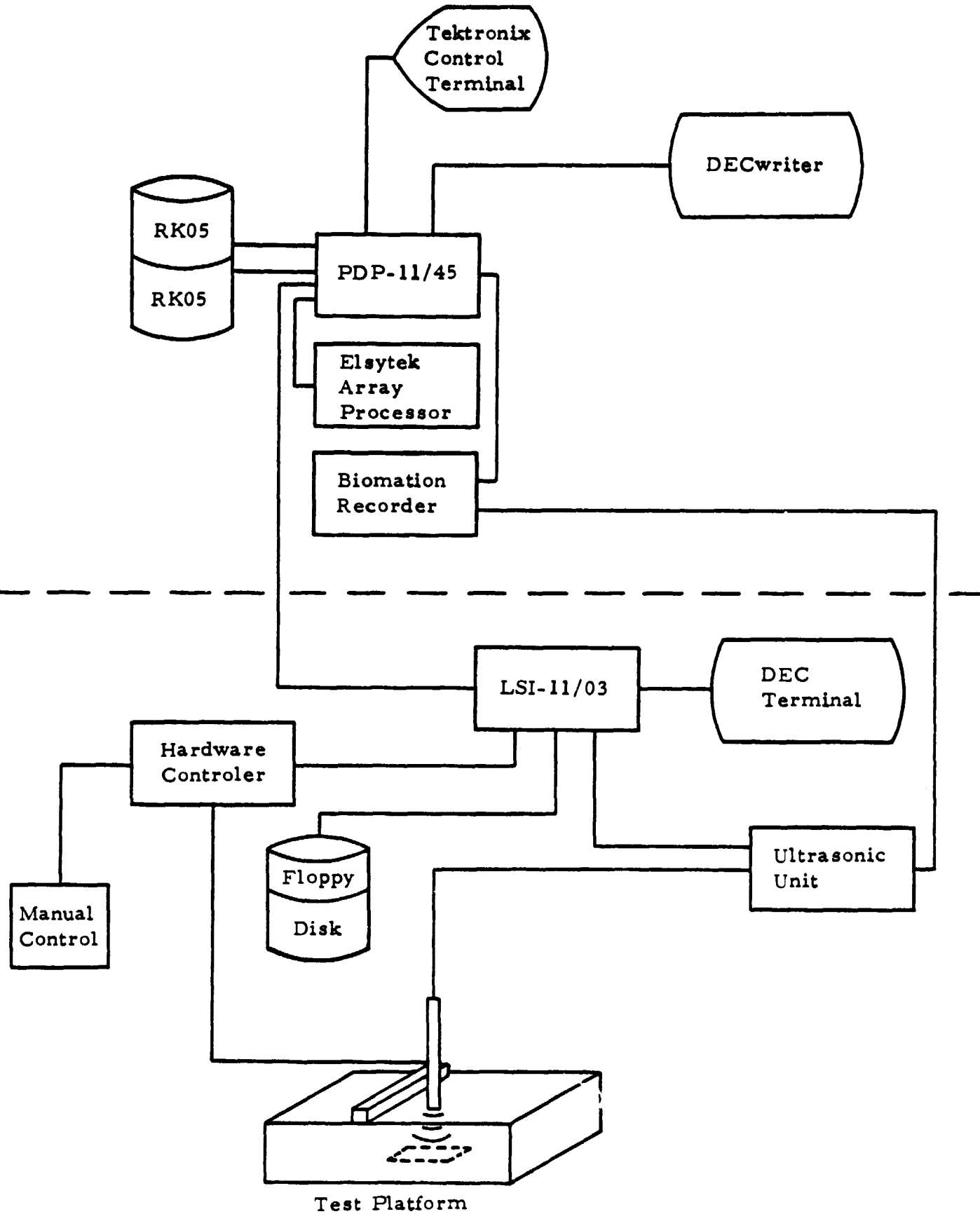


Figure 1-1

2. SYSTEM OVERVIEW

The ECHO1 System consists of two tasks: MNS, which resides on an RK05 Disk and is executed on the PDP-11/45, and KSCN2, which resides on a floppy disk and is executed on the LSI-11/03.

MNS provides operator interaction through the Tektronix terminal, controls data collection on the Biomation digital recorder, performs calculations on the Elsytek, and interfaces to the LSI-11/03.

KSCN2 receives commands from the PDP-11/45, positions the ultrasonic unit in the test platform using the Hardware Controller, and directs the ultrasonic unit to pulse and transmit returns to the Biomation Recorder.

Using the ECHO1 system, the operator can:

- Perform an amplitude threshcld X, Y scan of a part on the test platform.
- Using the crosshair at the Tektronix terminal, select a subregion of a displayed scan to be rescanned at higher resolution.
- Select a point within a displayed subscan to position the ultrasonic probe for detailed signal analysis.
- Display the returning signal data from the ultrasonic probe.
- Zoom in on a portion of the ultrasonic signals.
- Calculate and display the FFT of a selected portion of the ultrasonic signal.
- Zoom in on portions of the displayed FFT.
- Perform digital filtering of the FFT with up to eight windows.
- Calculate and display the inverse FFT.
- Perform signal averaging on up to 99 frames of data.

When MNS is executed on the PDP-11/45, the ECHO1 control display

will appear on the Tektronix terminal. From this terminal, the operator may select any of the control options, (SCAN, DISPLAY, ZOOM, etc.) at any time by typing the appropriate character. The following are all the control options currently available:

S = SCAN - Set up data acquisition.

D = DISPLAY - Select calculations and output.

A = AVERAGE - Multiple frames of input data.

Z = ZOOM - Adjust delay, sample internal and display limits for signal.

W = WINDOW FFT - Select digital filter.

X = EXAMINE FFT - Adjust display limits on FFT.

T = TRIGGER - Set trigger criteria for Biomation.

V = VIEW - Select subscan or point scan from an existing threshold plot.

E = EXIT - Terminate MNS.

P = PAUSE - Hold current display.

G = GO - Continue processing after pause or from control display.

2.1 TRIGGER Control

When the Biomation Digital Recorder is under control of the ECHO1 System, the front panel switches in the trigger section of the Recorder are disabled. This section is under digital control and may be accessed by the operator by pressing "T" on the control terminal.

When TRIGGER control is thus requested, the operator is prompted to select values for five parameters: Trigger Source, Trigger Slope, Trigger Coupling, Trigger Level Polarity, and Trigger Level.

The following example reflects the necessary trigger set-up for the hardware configuration described in this manual.

T
TRIGGER CONTROL REQUESTED
SELECT TRIGGER SOURCE
0 = EXTERNAL
1 = INTERNAL

1
SELECT TRIGGER SLOPE
0 = NEGATIVE
1 = POSITIVE

0
SELECT TRIGGER COUPLING
0 = DC
1 = AC

0
SELECT TRIGGER LEVEL POLARITY
0 = NEGATIVE
1 = POSITIVE

1
KEY IN 2-DIGIT TRIGGER LEVEL 9 0.

2.2 ZOOM Control

In the ECHO1 System, selection of parameters which affect what portion of a signal is to be recorded and what portion of the recorded signal is to be processed are not under direct operator control. Instead, the system determines these parameters based upon a single, simple operator input to ZOOM control.

ZOOM control is activated by pressing "Z" on the control terminal. This causes the system to acquire and display one frame of raw signal data, to prepare the terminal for graphic input via the joystick, and to display prompting information for the required input.

Input consists of positioning the graphic crosshair over the center of the portion of the displayed signal which is of interest. The operator then presses "I" to zoom in on this region or "O" to zoom out. The system uses this input to determine values for the recording sample interval, recording delay after trigger, display start time, and display range.

Figures 2-1 through 2-7 demonstrate the operating characteristics of ZOOM.

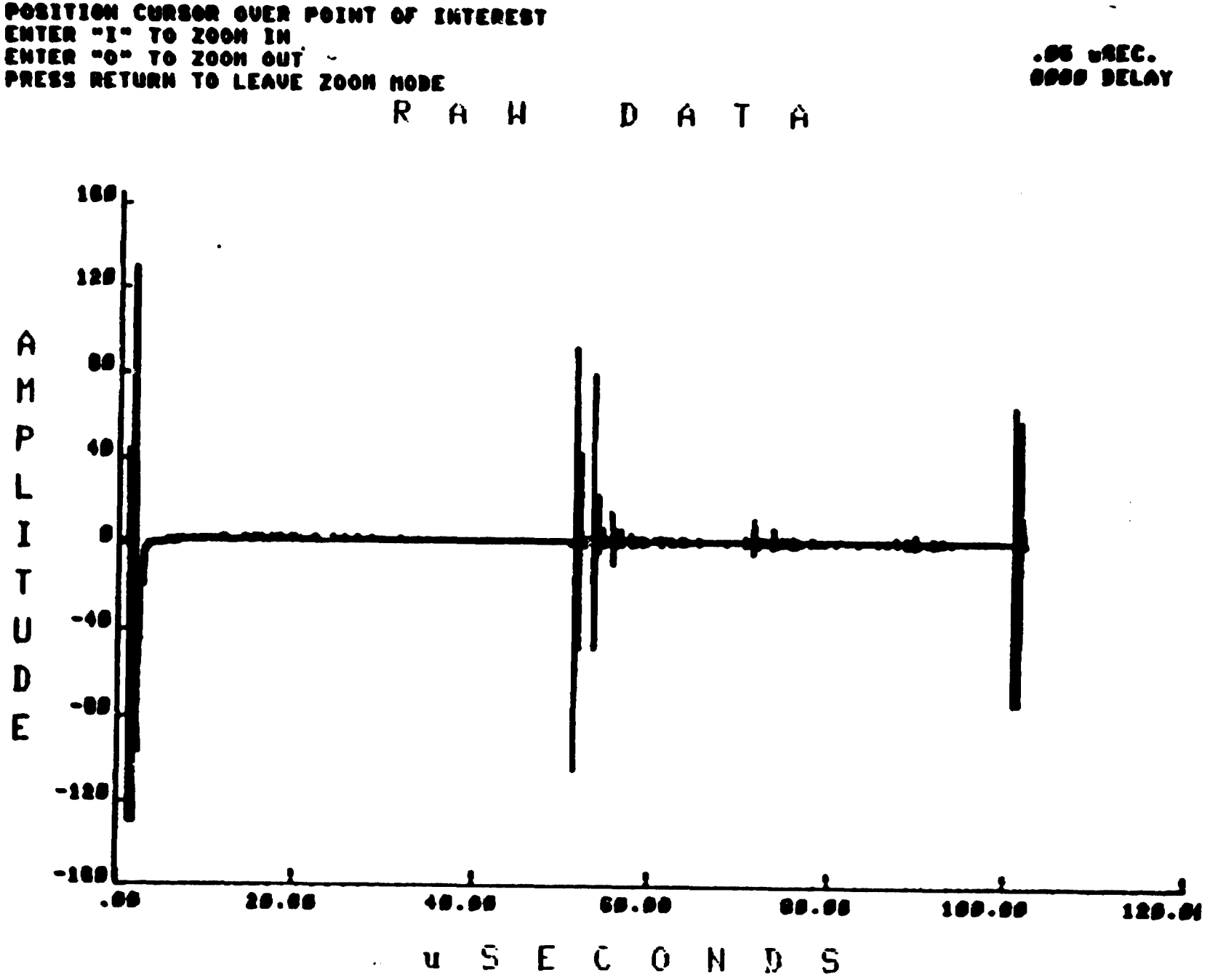
2.3 SCAN Control

ECHO1 allows several modes of data collection: REAL TIME SCAN, REAL TIME NO SCAN, SAME SCAN, and SIMULATED. In REAL TIME modes, SCAN indicated the moving of the probe before each display, while NO SCAN means that the probe remains stationary. In both these modes, the signal is reacquired before each display. In SAME SCAN mode, the last signal acquired is maintained in the system for all displays. SIMULATED data mode is covered in the Appendix.

All modes of data collection are selected in SCAN control after entering "S" at the control terminal. The following example demonstrates the use of scanner control to select a REAL TIME SCAN.

```
S
SCANNER CONTROL REQUESTED
SELECT INPUT SOURCE
0 = SIMULATED DATA
1 = REAL TIME DATA
2 = RECORDED DATA
3 = SAME SCAN

1
        (Note: ECHO1 does not currently support Input Source 2.)

SELECT REAL TIME MODE
0 = NO SCAN
1 = SCAN
2 = RESCAN at NEW THRESHOLD

1
        (Note: The selection of Option 2 at this point simply
        causes scan limit input to be skipped.)

ENTER SCAN LIMITS
USING REMOTE CONTROL:
TOGGLE M, POSITION SCANNER TO LOWER LIMIT.
PRESS RESET TO SEND COORDINATES.
POSITION SCANNER TO UPPER LIMIT.
TOGGLE C, PRESS RESET TO SEND COORDINATES.
COMPUTER WILL VERIFY COORDINATE RECEIVED WITH BELL.
```

EXAMPLE DEMONSTRATING THE USE OF ZOOM



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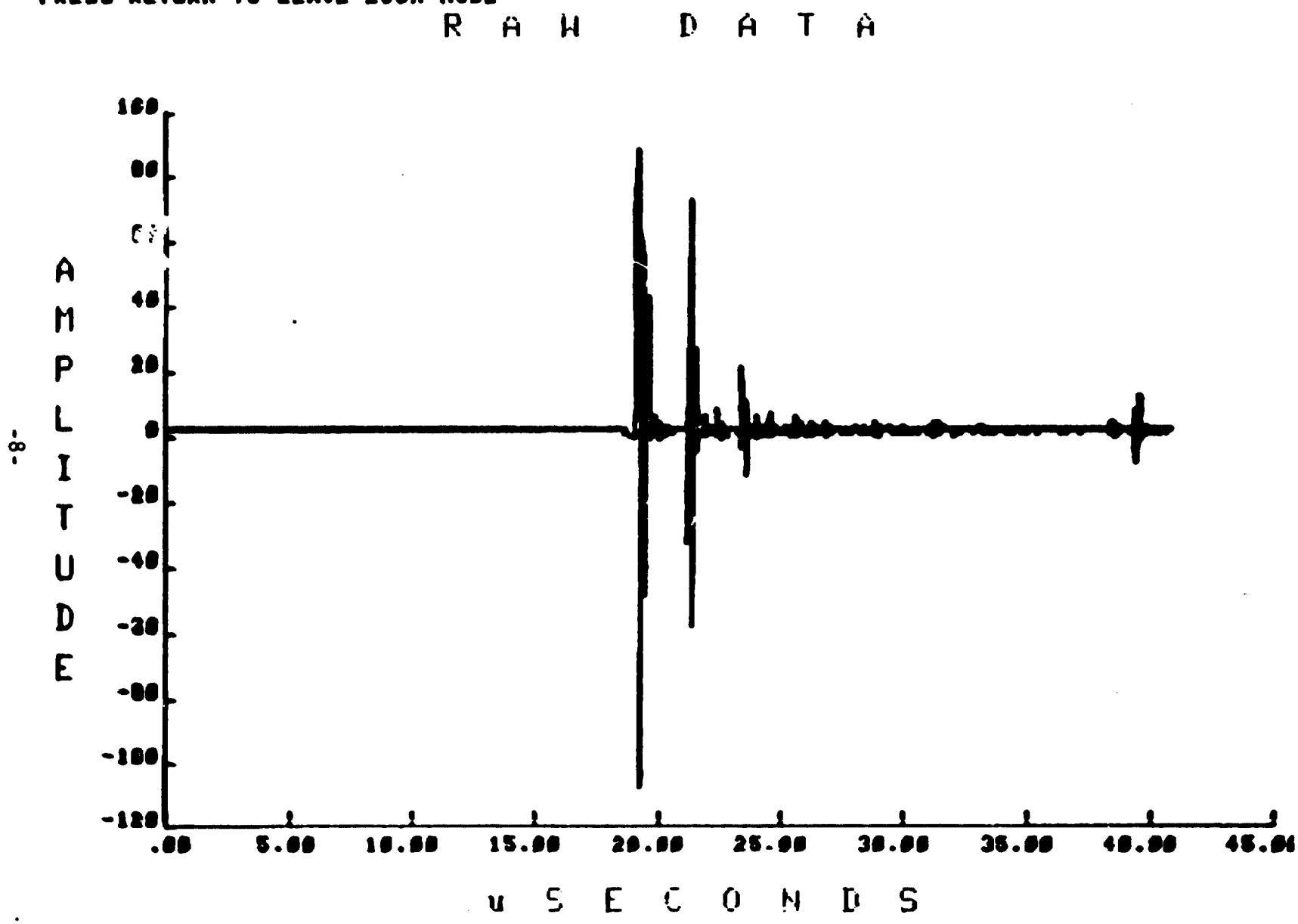
POSITION CURSOR OVER POINT OF INTEREST
ENTER "I" TO ZOOM IN
ENTER "O" TO ZOOM OUT
PRESS RETURN TO LEAVE ZOOM MODE

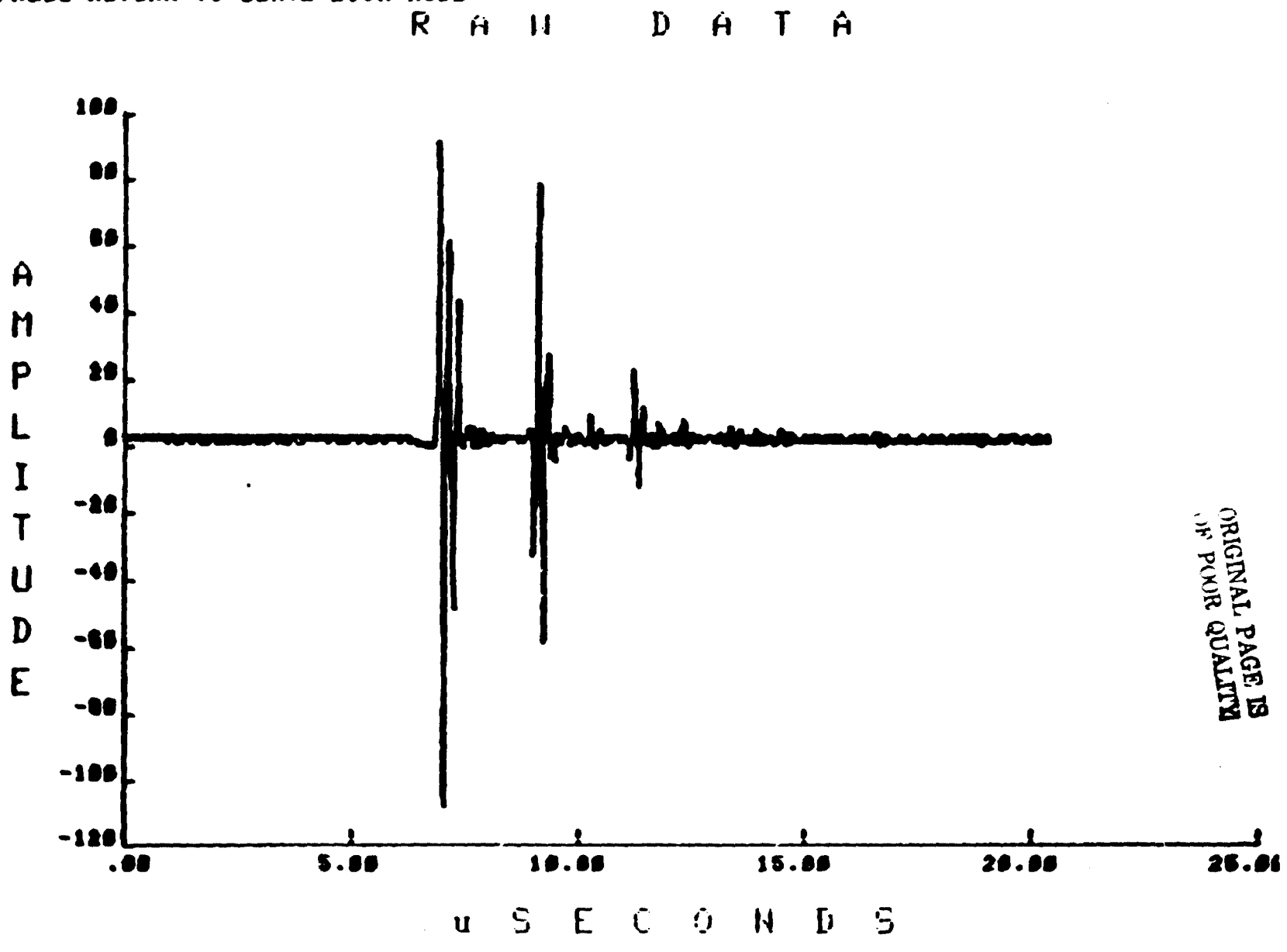
.02 uSEC.
1540 DELAY



EXAMPLE DEMONSTRATING THE USE OF ZOOM

POSITION CURSOR OVER POINT OF INTEREST
ENTER "I" TO ZOOM IN
ENTER "O" TO ZOOM OUT
PRESS RETURN TO LEAVE ZOOM MODE

.01 uSEC.
4270 DELAY



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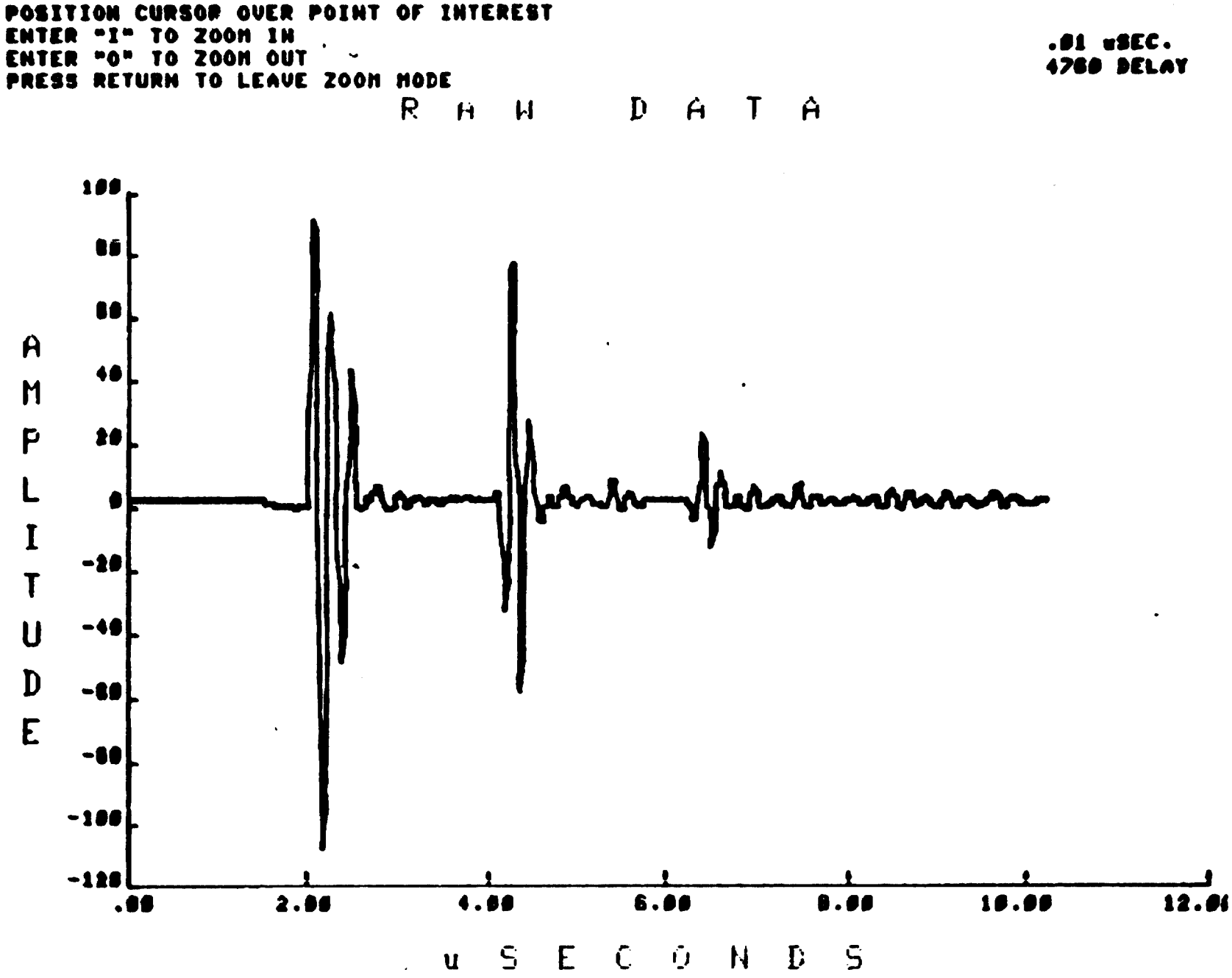
EXAMPLE DEMONSTRATING THE USE OF ZOOM



EXAMPLE DEMONSTRATING THE USE OF ZOOM

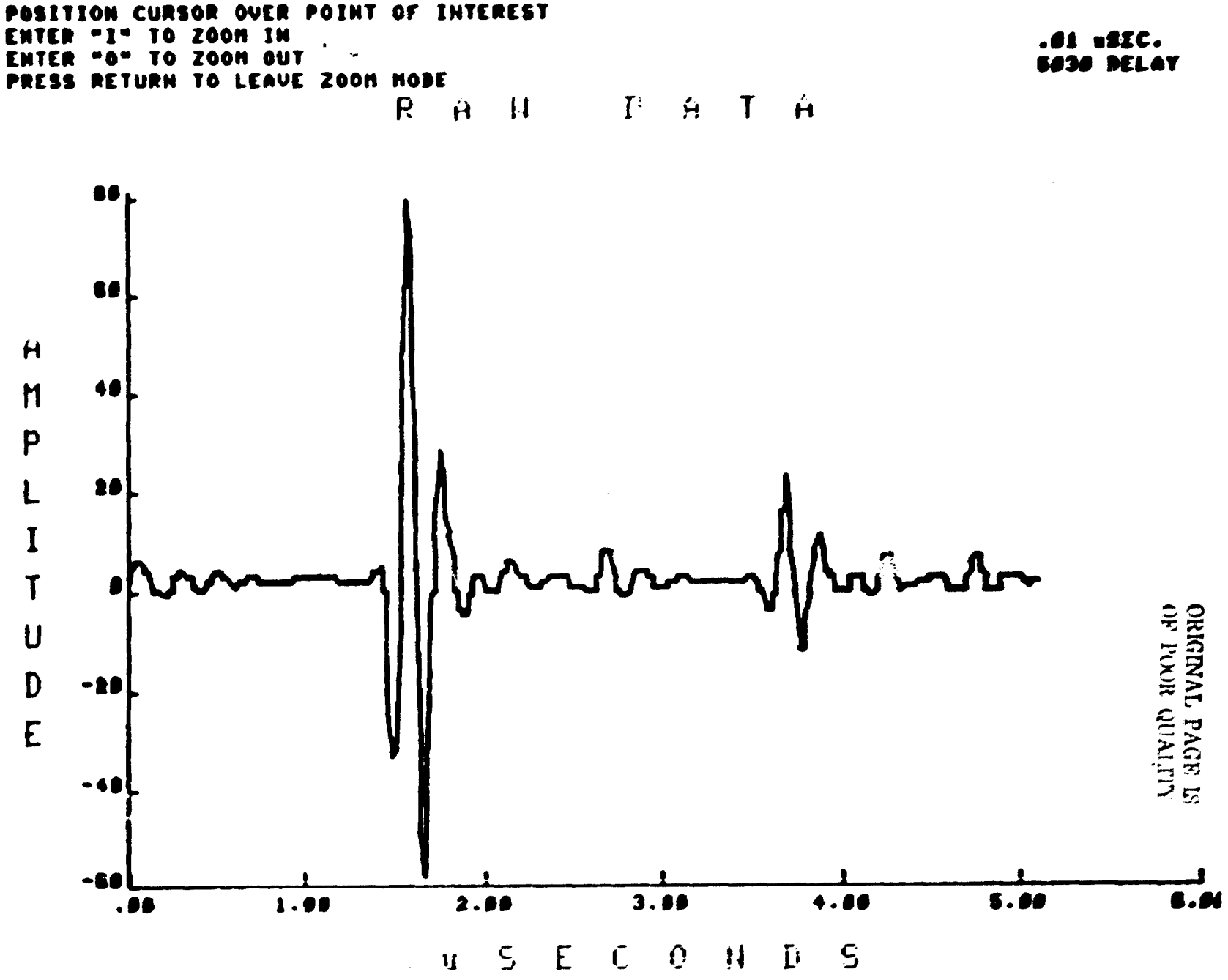
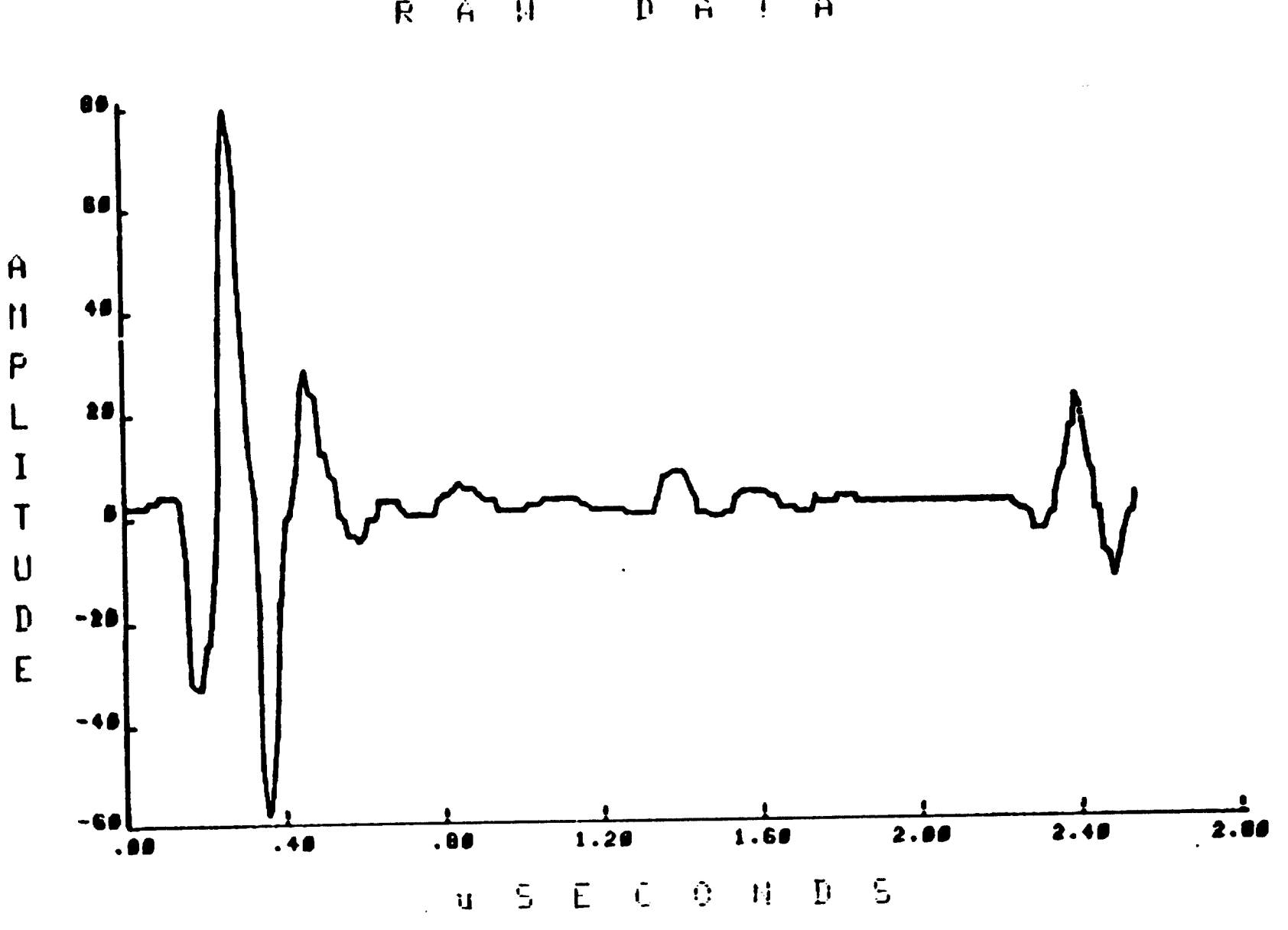


Figure 2-5

EXAMPLE DEMONSTRATING THE USE OF ZOOM

POSITION CURSOR OVER POINT OF INTEREST
ENTER "I" TO ZOOM IN
ENTER "O" TO ZOOM OUT
PRESS RETURN TO LEAVE ZOOM MODE

.01 uSEC.
6160 DELAY



EXAMPLE DEMONSTRATING THE USE OF ZOOM

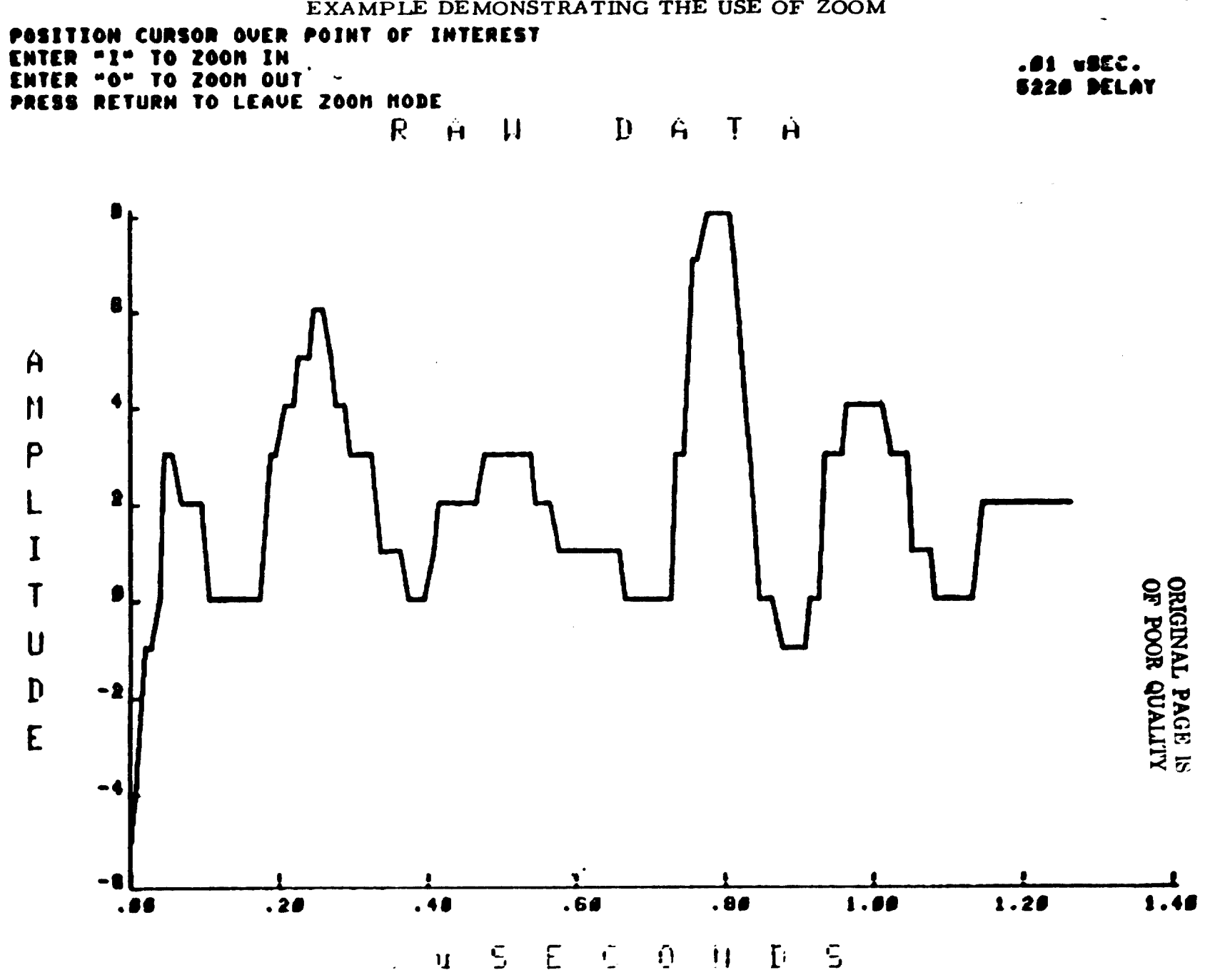


Figure 2-7

(Note: When the above instructions are carried out using the remote control unit attached to the ultrasonic test bed, then the following prompt will be displayed.)

KEY IN SCAN THRESHOLD 00-99 2 0

In the previous example, the SCAN threshold value corresponds to 20 percent of the maximum signal amplitude. This value is used in REAL TIME SCAN mode to generate threshold plots of signal data acquired in rectangular scans.

2.4 VIEW Control

Once a threshold scan of a rectangular region has been completed, it is possible to request multiple subscans of this region to be performed at higher resolution than the original scan. Once a subscan of a region is defined, it is possible to position the scanner over single points within the subregion for detailed signal analysis. These functions are performed in VIEW control which is accessed by pressing "V" on the control terminal.

Upon entry to VIEW control, the following prompt is displayed.

SELECT VIEW MODE
0 = DEFINE NEW SUBSCAN
1 = DEFINE NEW POINT SCAN

If DEFINE NEW SUBSCAN is selected, then the primary threshold scan is displayed, the terminal is placed in GRAPHIC INPUT mode, and a prompt is displayed requesting that two points be entered to define the subregion for a secondary threshold scan.

If DEFINE NEW POINT SCAN is selected, then the secondary threshold scan is displayed, the terminal is placed in GRAPHIC INPUT mode, and a prompt is displayed requesting that a single point be entered to position the scanner for stationary signal analysis.

Figures 2-8 and 2-9 are threshold scans from VIEW control:

2.5 DISPLAY Control

There are six graphic displays available within the ECHO1 system. The operator may choose the display he is interested in by pressing "D" on the control terminal. In DISPLAY control, the operator is prompted

THRESHOLD SCAN FROM VIEW CONTROL

SUB SCAN
USING CURSOR SELECT OPPOSITE CORNERS OF SCAN
PRESS RETURN TO ENTER COORDINATE

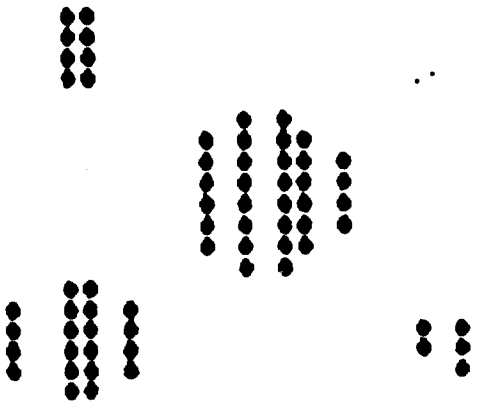


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Figure 2-8

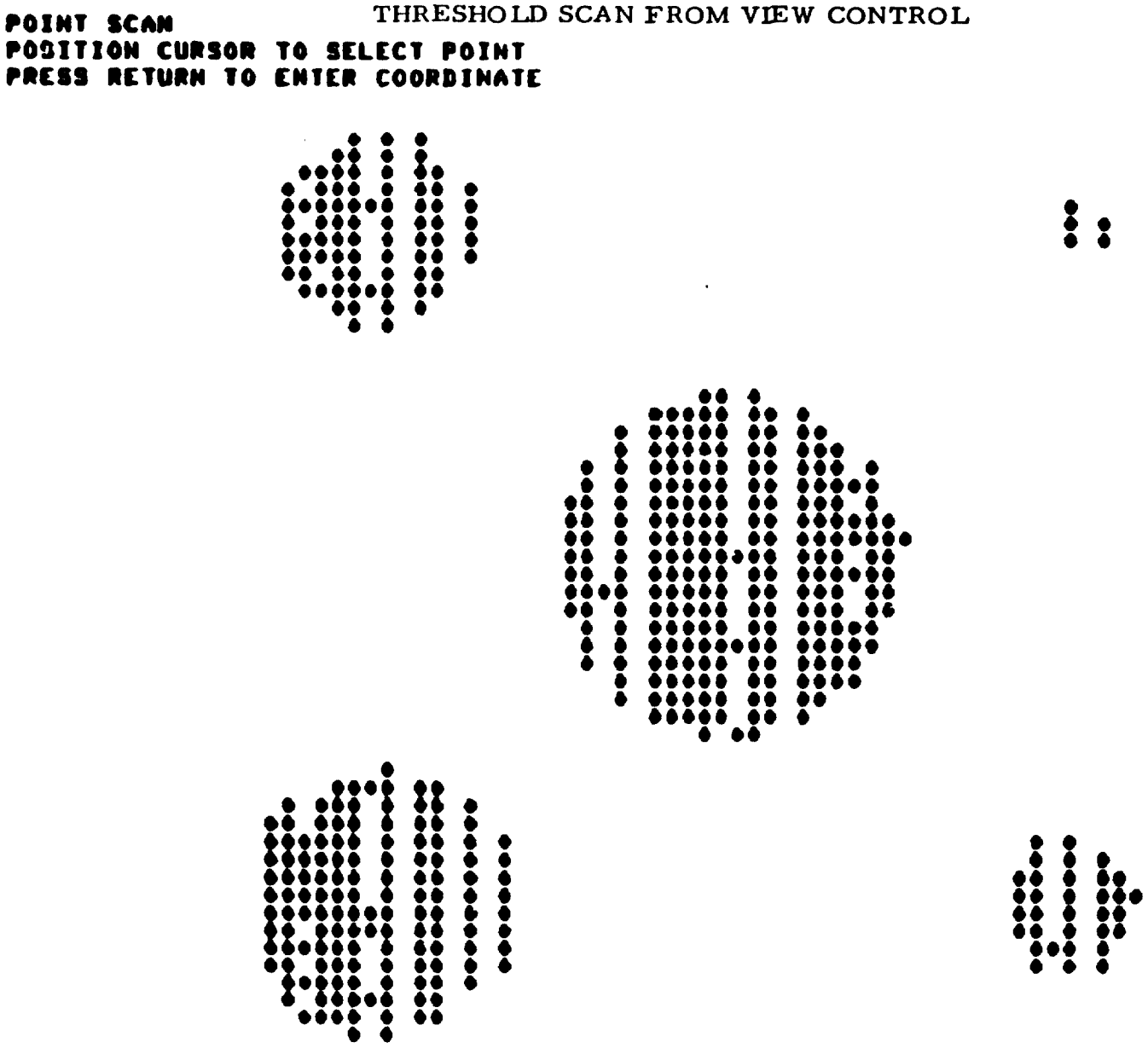

POINT SCAN
POSITION CURSOR TO SELECT POINT
PRESS RETURN TO ENTER COORDINATE
THRESHOLD SCAN FROM VIEW CONTROL

Figure 2-9

to select one of the display types. The type selected becomes the active display and will be plotted at the end of each data collection cycle. All scaling, labeling, and calculations necessary to generate the displays are selected automatically.

Figures 2-10 through 2-15 are examples of each display type. The first four are typical signal analysis plots. The last two display the contents of the 64 x 64 scan grids that are used by VIEW control.

2.6 AVERAGING Control

When data is being acquired from a stationary probe, it is possible to average the returns from multiple pulses in order to eliminate random noise. The ECHO1 system allows up to 99 pulses to be averaged prior to performing calculations and display. To select AVERAGING, the operator presses "A" at the control console. The operator is prompted to enter the number of scans (pulses) to be averaged. AVERAGING remains in effect until the operator returns to AVERAGING control and selects zero or one scans to be averaged.

2.7 EXAMINE FFT

When a FFT display is selected, the range of frequencies plotted is a function of the number of points processed. As a result of this default, most FFT displays contain more data than the operator is interested in, and the data the operator wants is compressed and difficult to read. To solve this problem, the ECHO1 System provides a capability similar to ZOOM which allows the operator to select any portion of the FFT plot to be displayed.

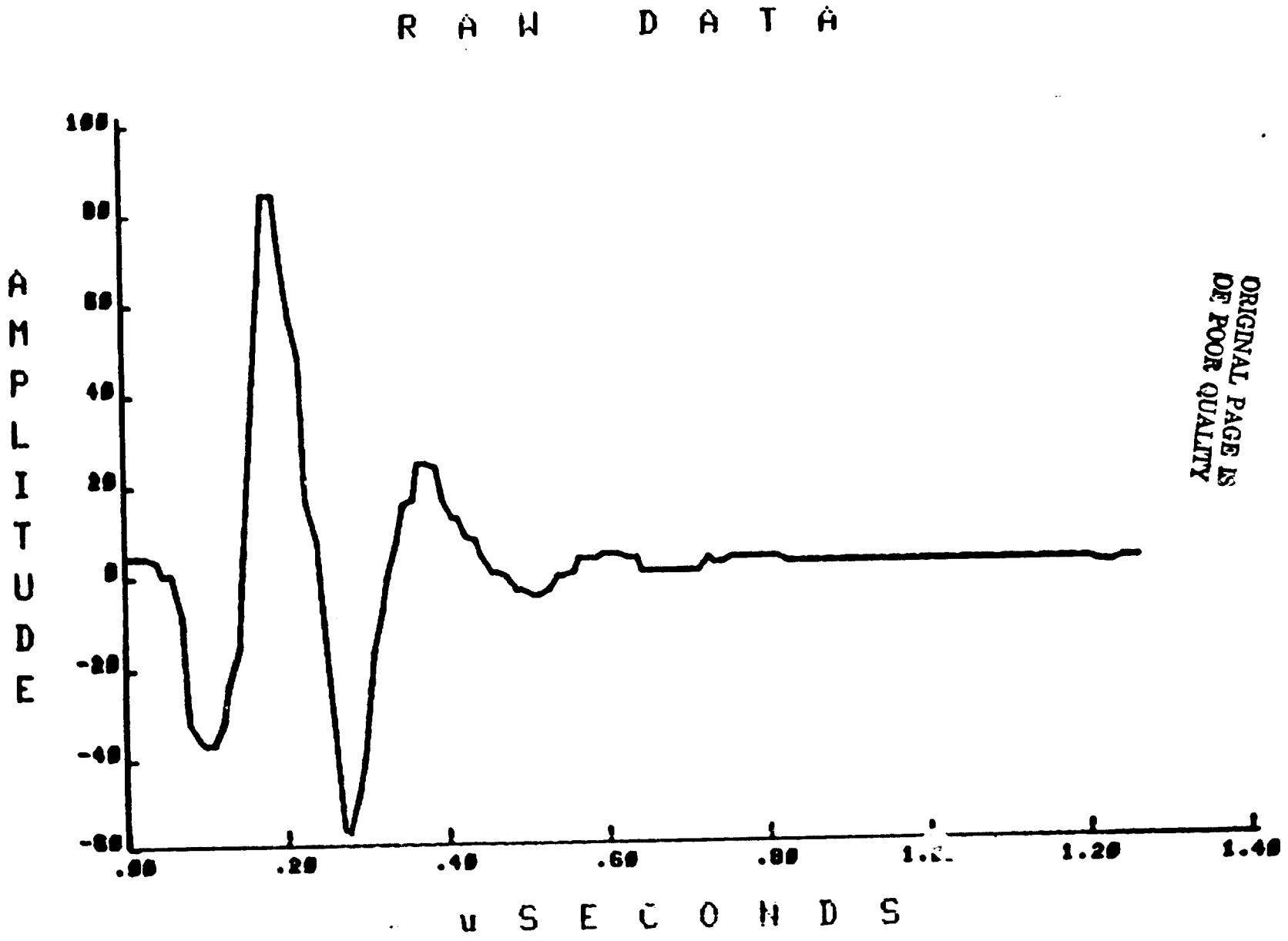
The EXAMINE capability is accessed by pressing "X" on the control terminal. This causes the system to acquire one frame of data, to calculate and display the FFT, to prepare the terminal for graphic input, and to display prompting information for the required input. As with ZOOM, this input consists of positioning the graphic crosshair over the center of the region of interest, then pressing "I" to zoom in on this point or "O" to zoom out from this point.

Figures 2-16 through 2-18 demonstrate the use of EXAMINE to zoom in on a FFT.

DISPLAY TYPE

PAUSE

.01 uSEC.
5228 DELAY



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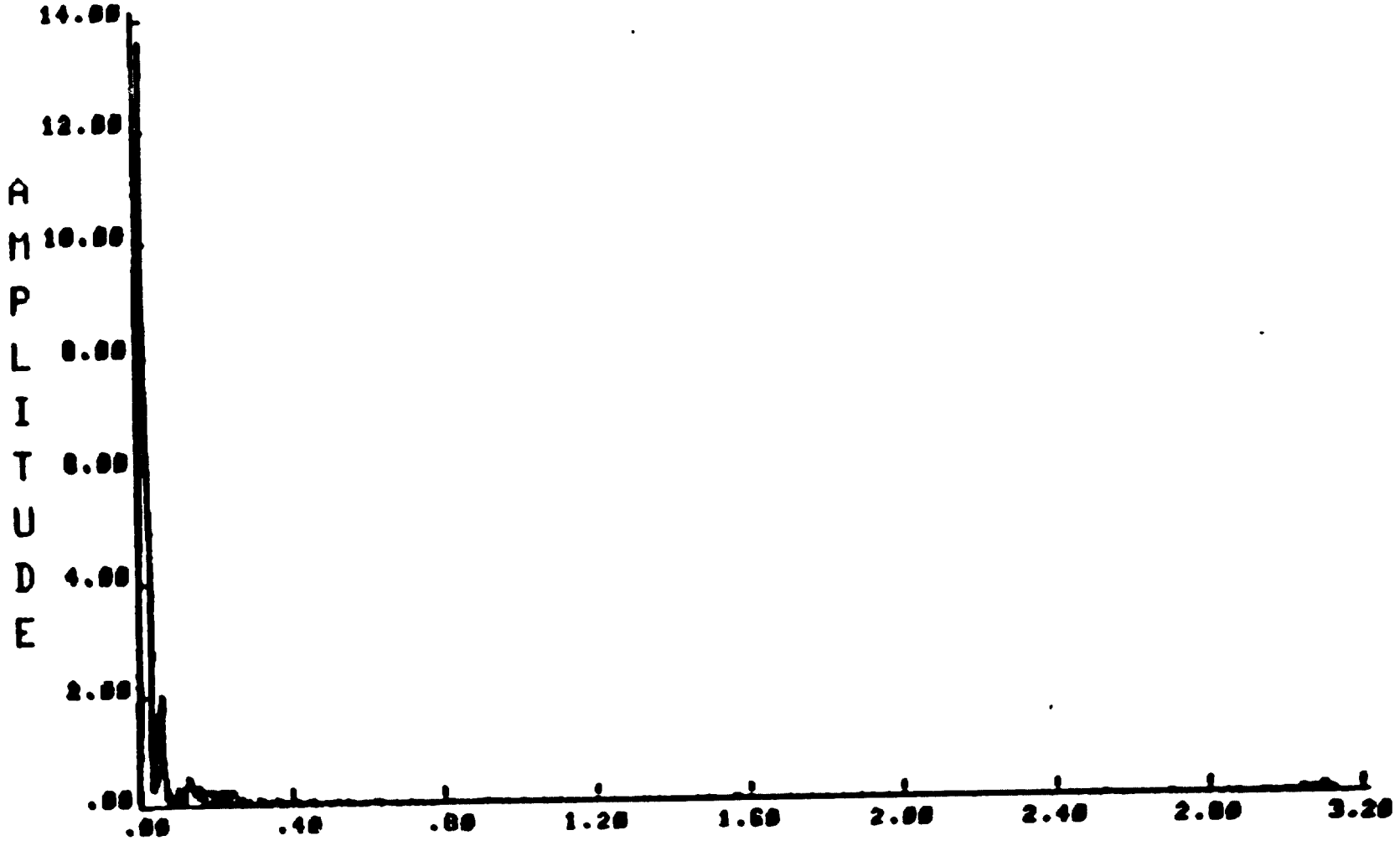
DISPLAY TYPE

PAUSE

.01 uSEC.
S220 DELAY
INTERPOLATING

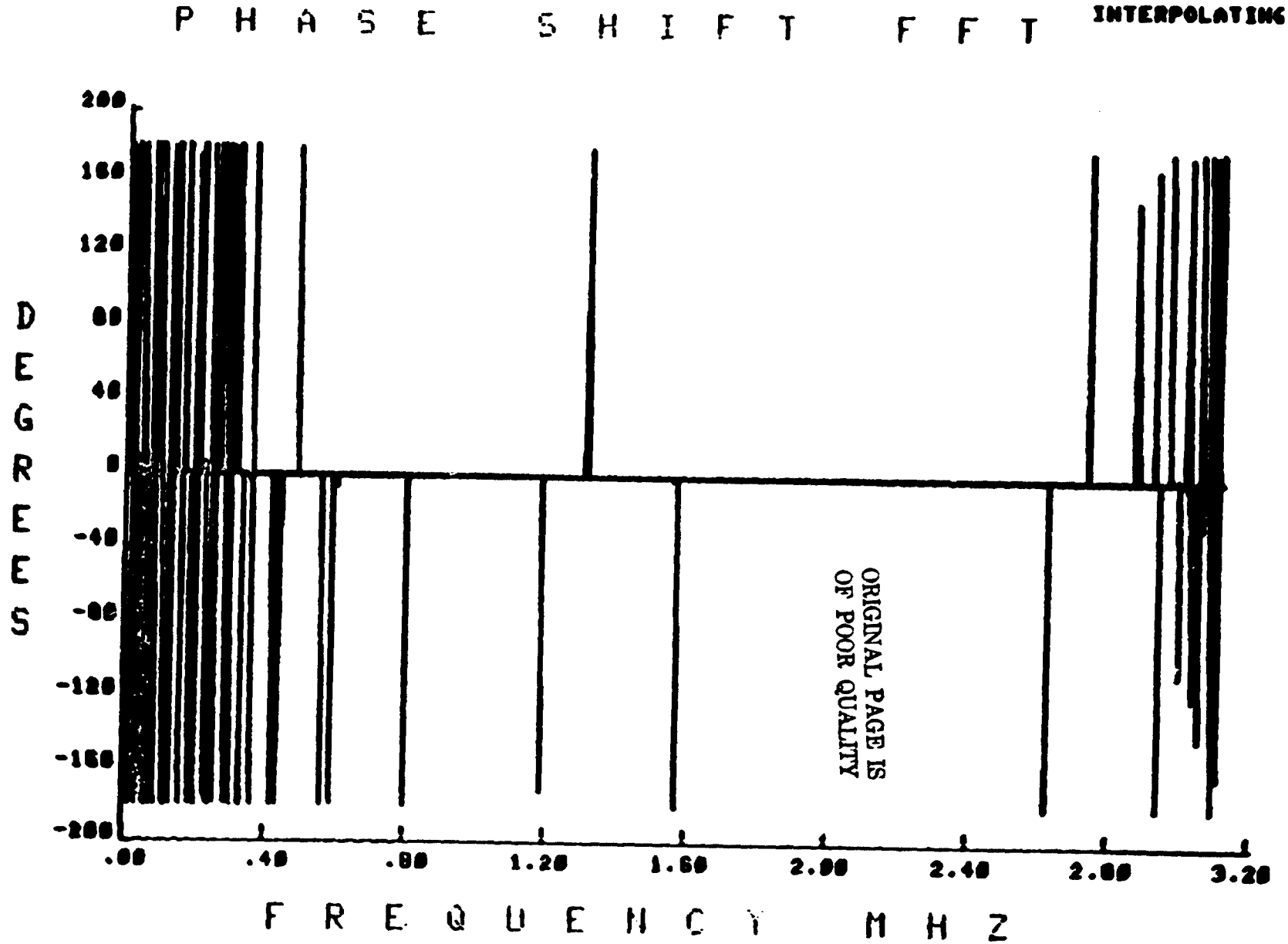
MAGNITUDE FFT



PAUSE

DISPLAY TYPE

.01 uSEC.
5220 DELAY
INTERPOLATING



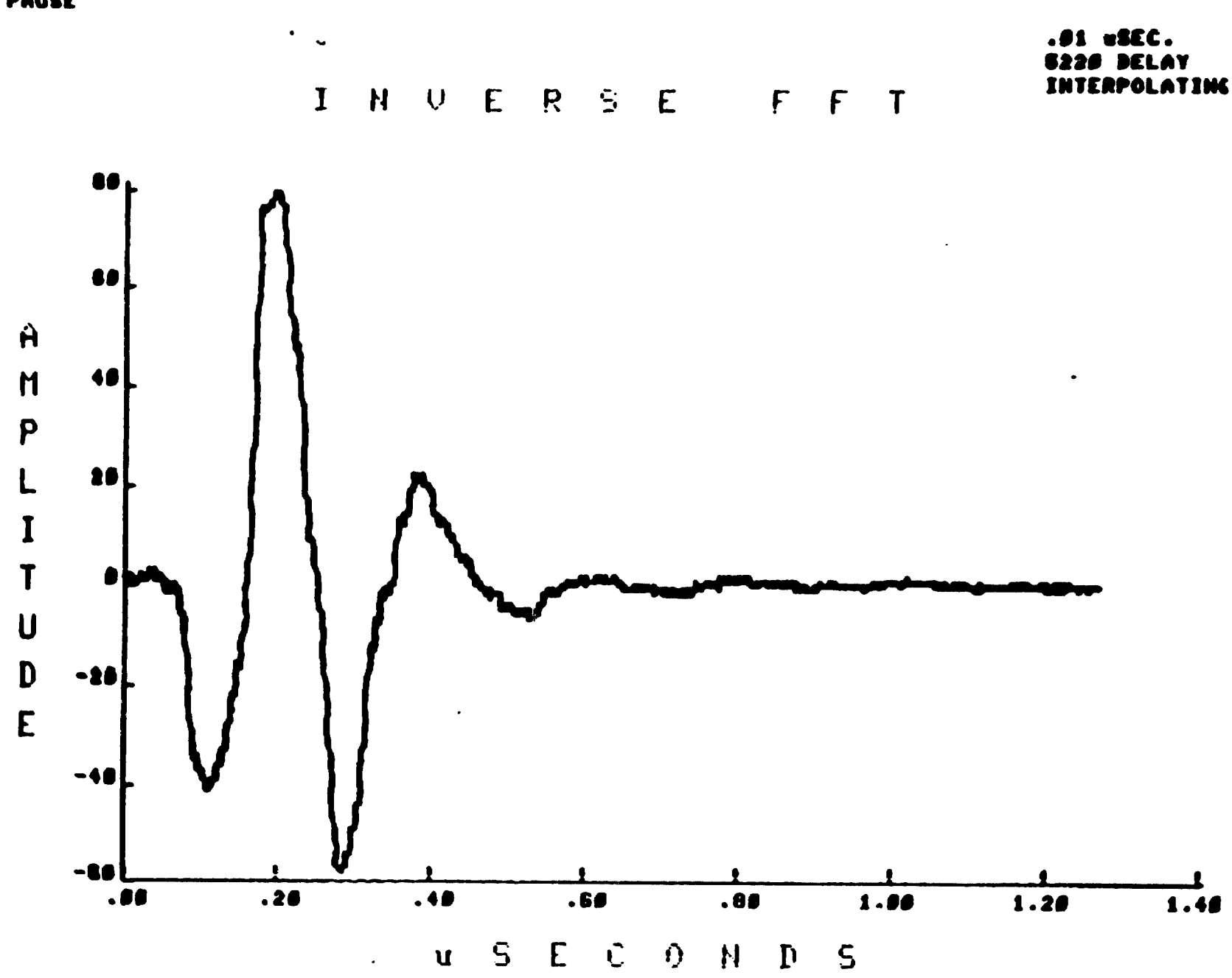

PAUSE
.01 uSEC.
8220 DELAY
INTERPOLATING
I N V E R S E F F T
AMPLITUDE
80
60
40
20
0
-20
-40
-80
.00
.20
.40
.60
.80
1.00
1.20
1.40
u S E C O N D S

Figure 2-13

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DISPLAY TYPE

Figure 2-14

DISPLAY TYPE

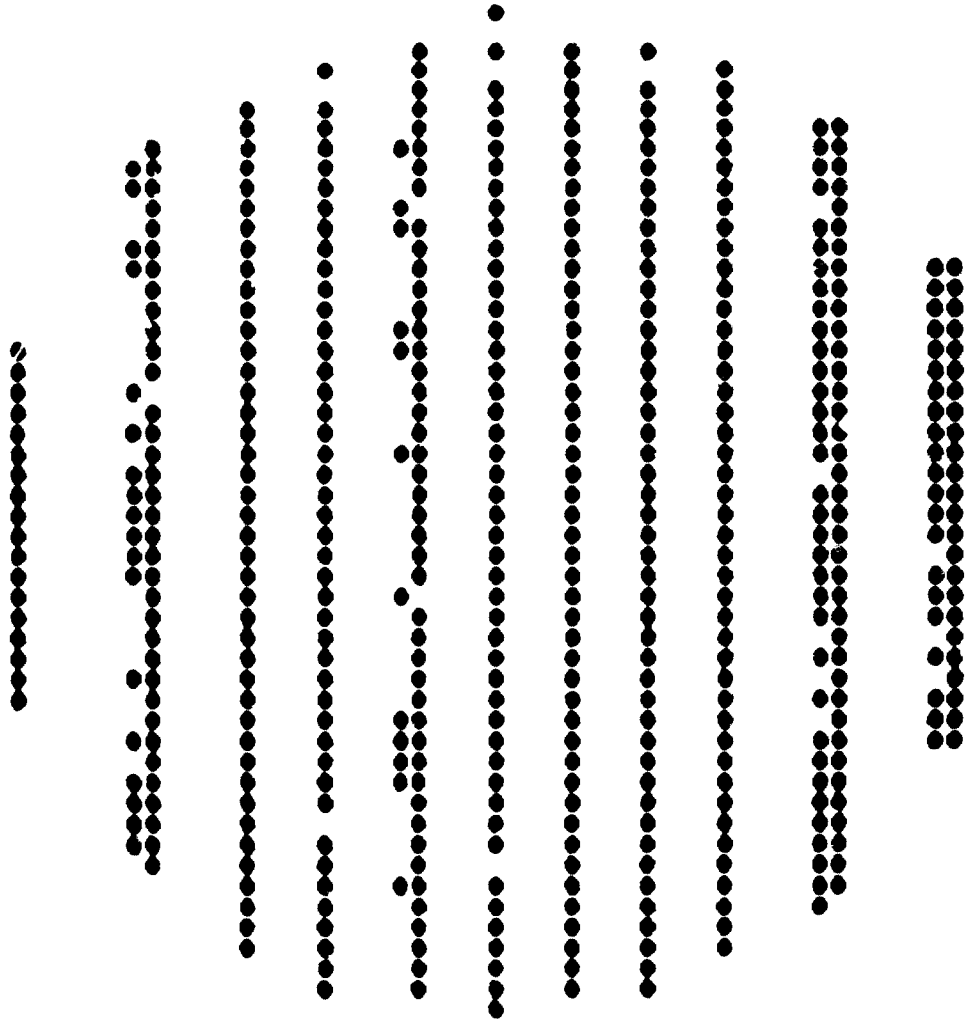

Figure 2-15

EXAMPLE OF THE USE OF EXAMINE

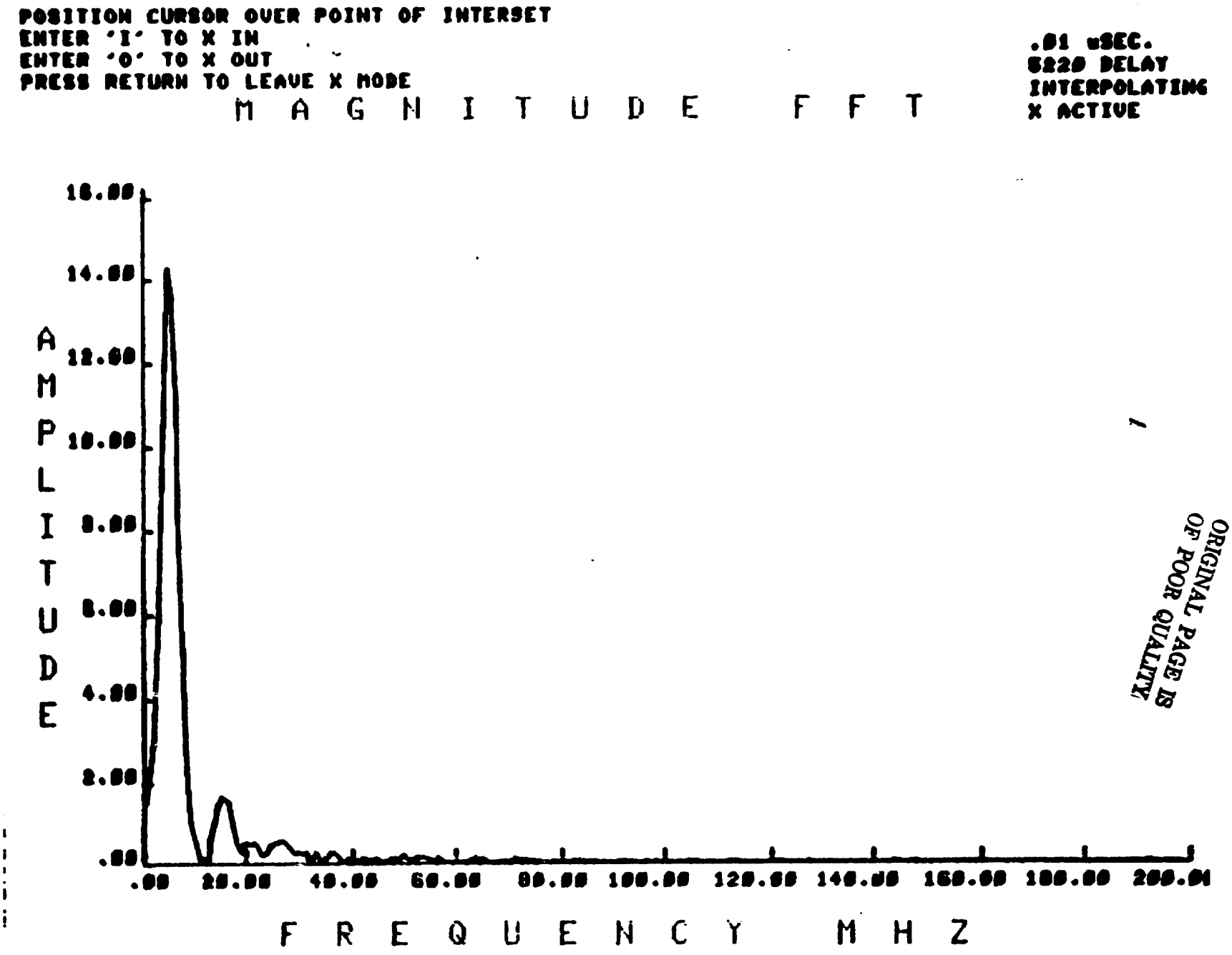

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Figure 2-16

EXAMPLE OF THE USE OF EXAMINE

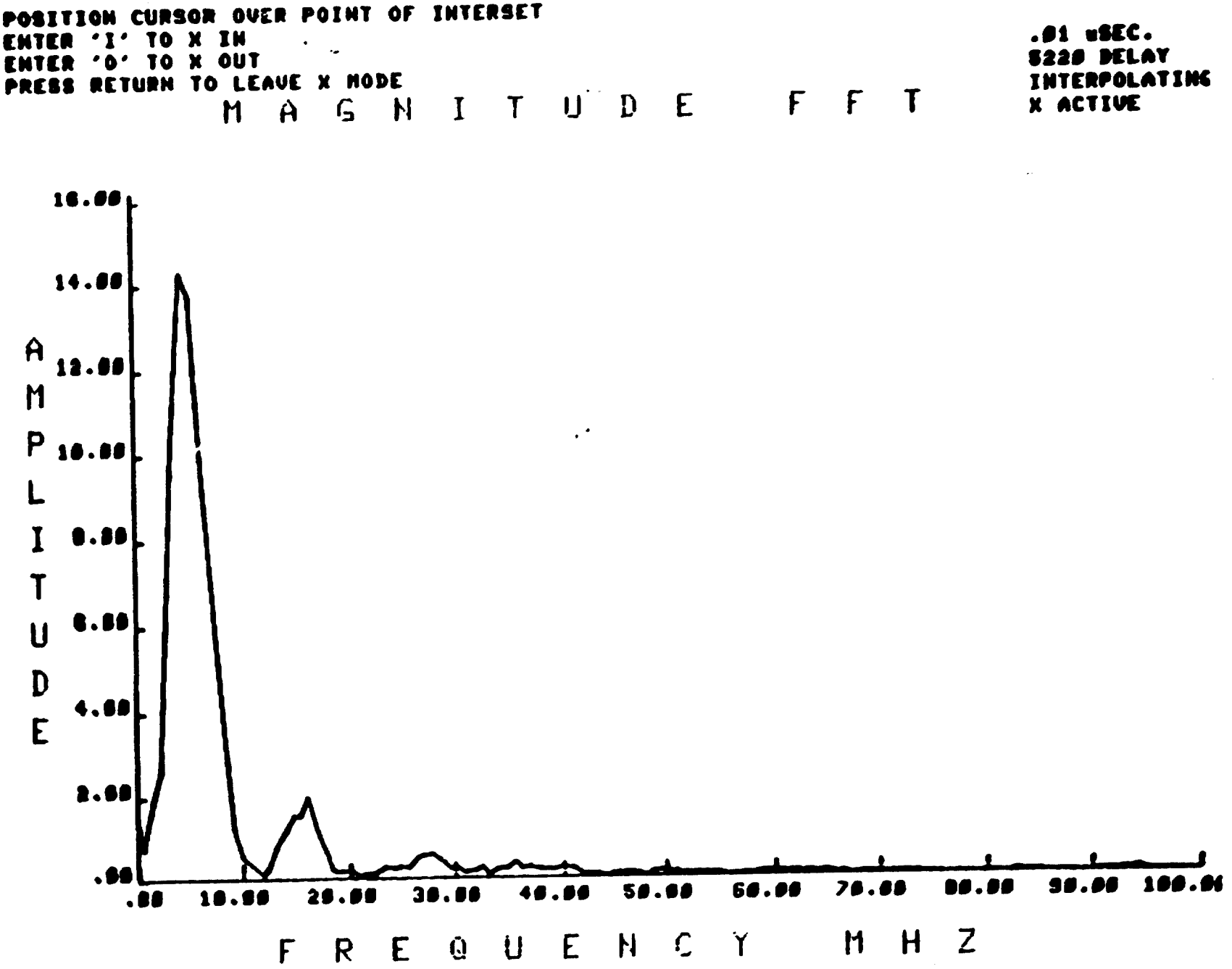

Figure 2-17

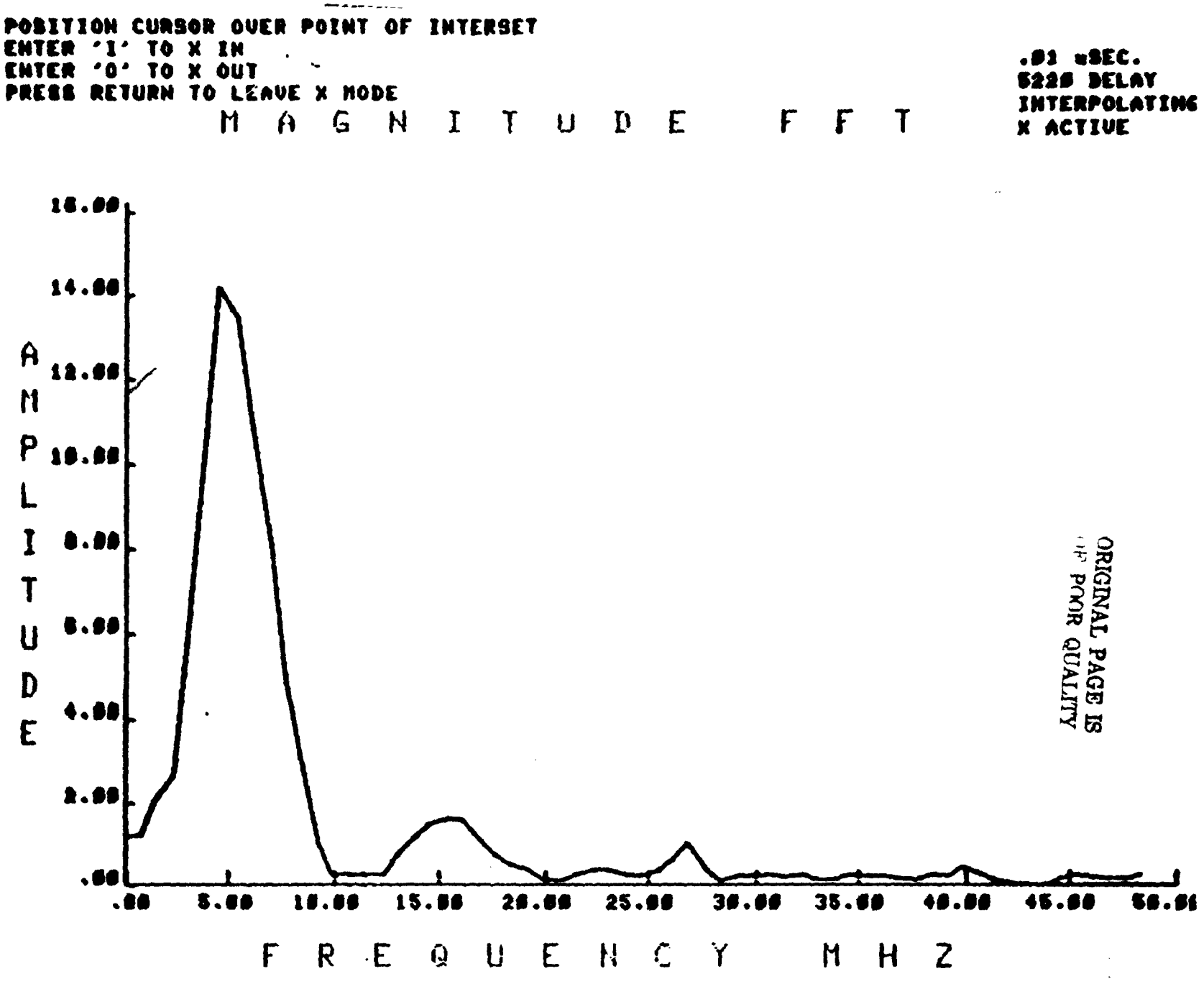
POSITION CURSOR OVER POINT OF INTERSET
ENTER '1' TO X IN
ENTER '0' TO X OUT
PRESS RETURN TO LEAVE X MODE
.01 uSEC.
5228 DELAY
INTERPOLATING
X ACTIVE
M A G N I T U D E F F T
AMPLITUDE
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
.00
.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
F R E Q U E N C Y M H Z
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Figure 2-18

2.8 WINDOW FFT

For most types of signal data, an operator will know the frequency range of his data and the frequencies at which noise will occur. In the ECHO1 system, it is possible to produce an Inverse FFT signal plot which includes only those frequencies which the operator is interested in. This capability is provided through WINDOW FFT which is accessed by pressing "W" on the control terminal.

After selecting WINDOW control, the operator is prompted to select WINDOW type. Currently, only WINDOW type 0 is supported. Selection of type 0 will cause one frame of data to be collected, the FFT to be calculated and plotted, the terminal to be initialized for graphic input, and prompt messages to be displayed. In WINDOW mode, the operator may define up to eight windows. After each window is defined, the display is updated and only the portions of the FFT which are within the range of a window are plotted. Upon leaving WINDOW mode, only the portions of the FFT within the defined windows are processed by the Inverse FFT function.

Accurate window placement is possible by using the EXAMINE FFT function in conjunction with the WINDOW function.

Windows are automatically deleted when ZOOM is requested. Individual windows are deleted in WINDOW mode by identifying a window corner with the corsshair and pressing "-" on the keyboard. Figures 2-19 through 2-26 are examples of the use of WINDOW mode.

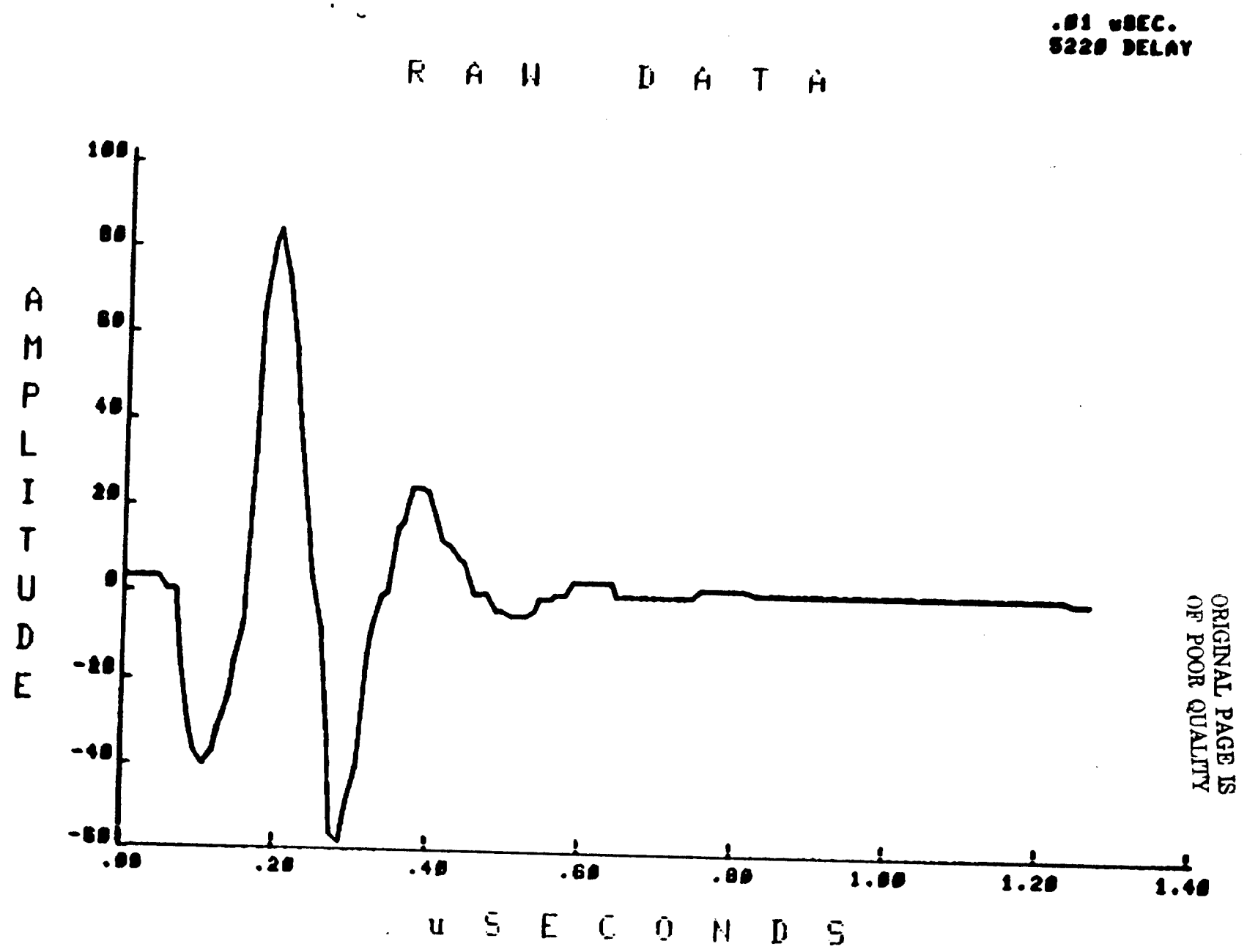

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Figure 2-19

EXAMPLE OF THE USE OF WINDOW MODE

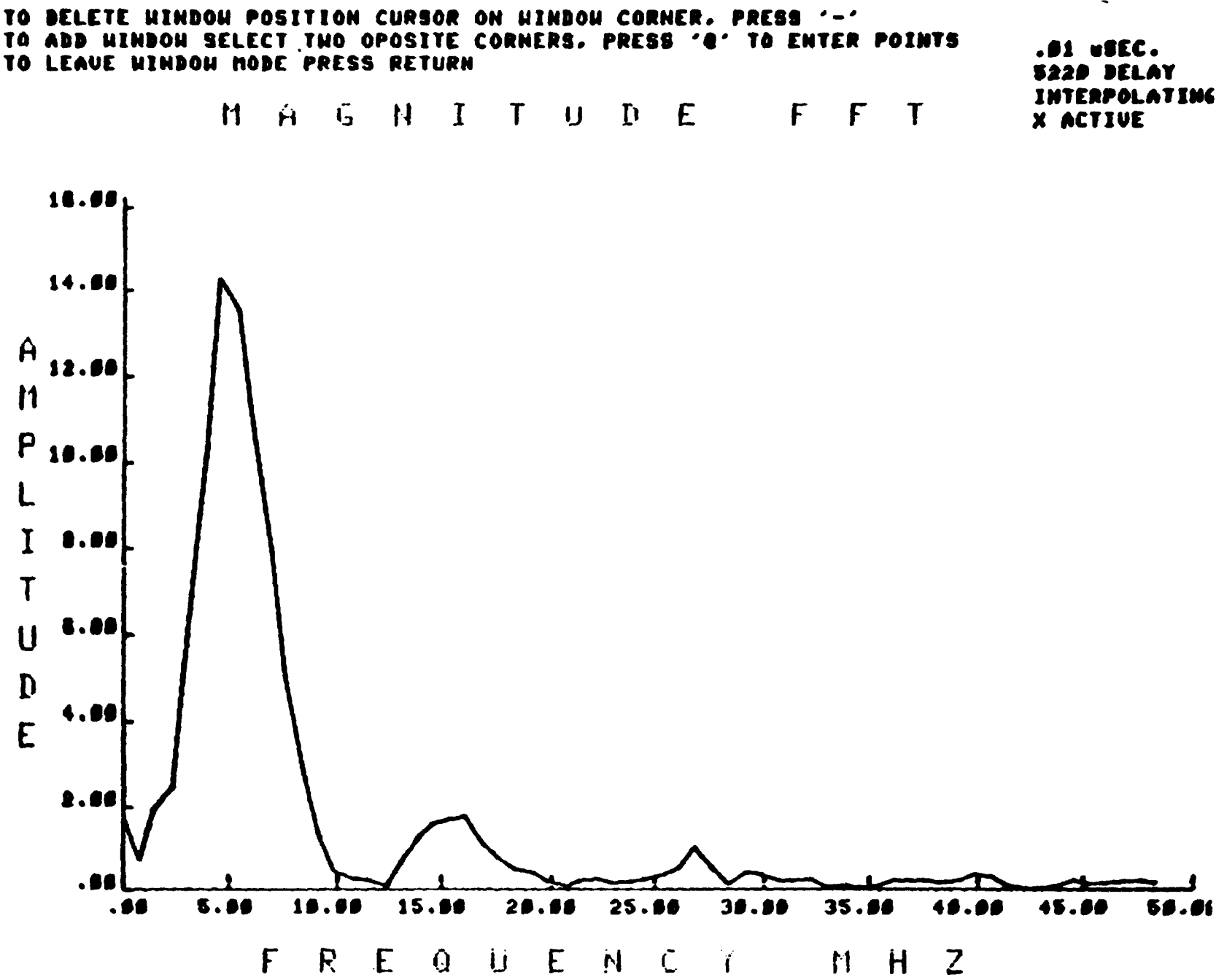

Figure 2-20

EXAMPLE OF THE USE OF WINDOW MODE

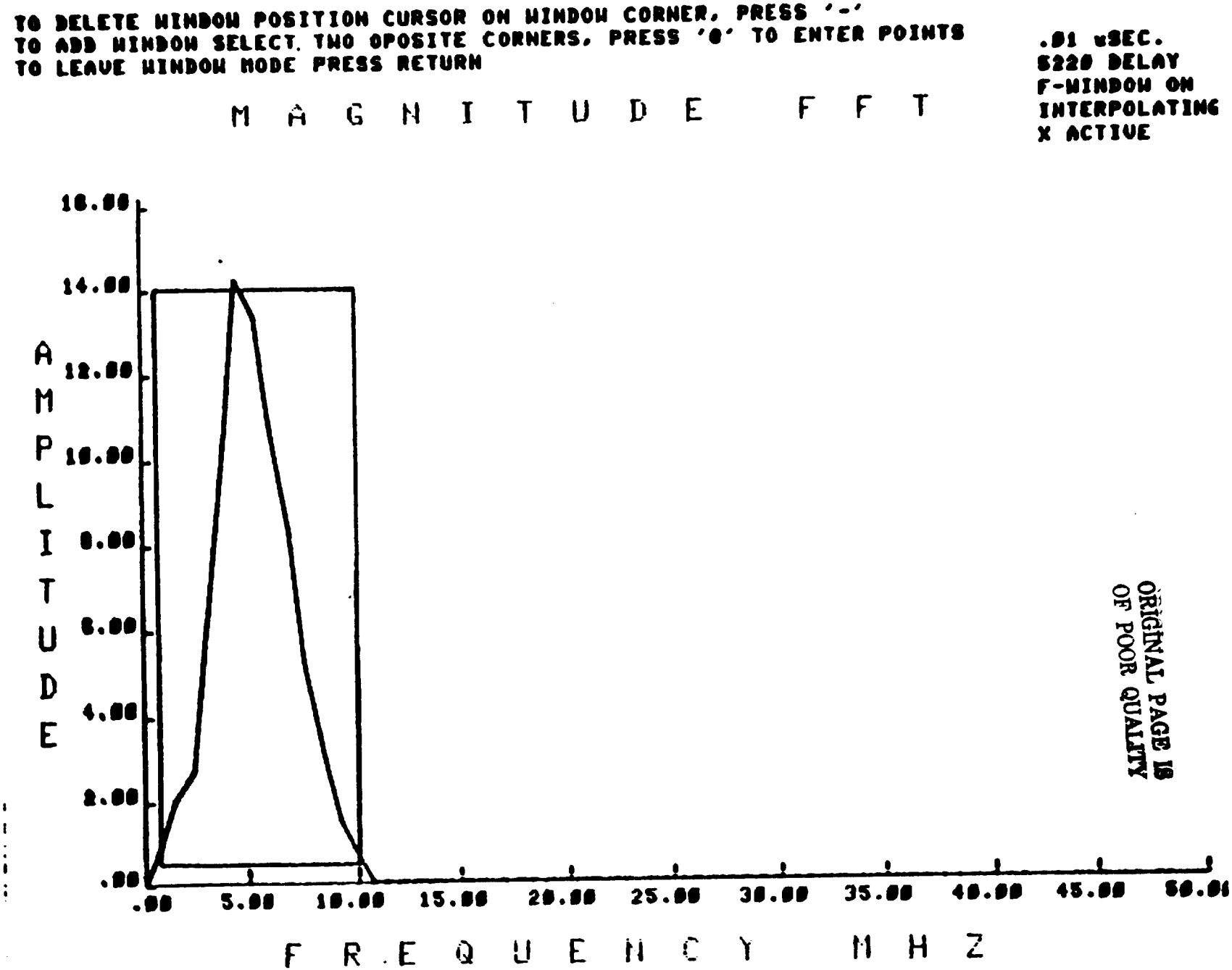

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Figure 2-21

EXAMPLE OF THE USE OF WINDOW MODE

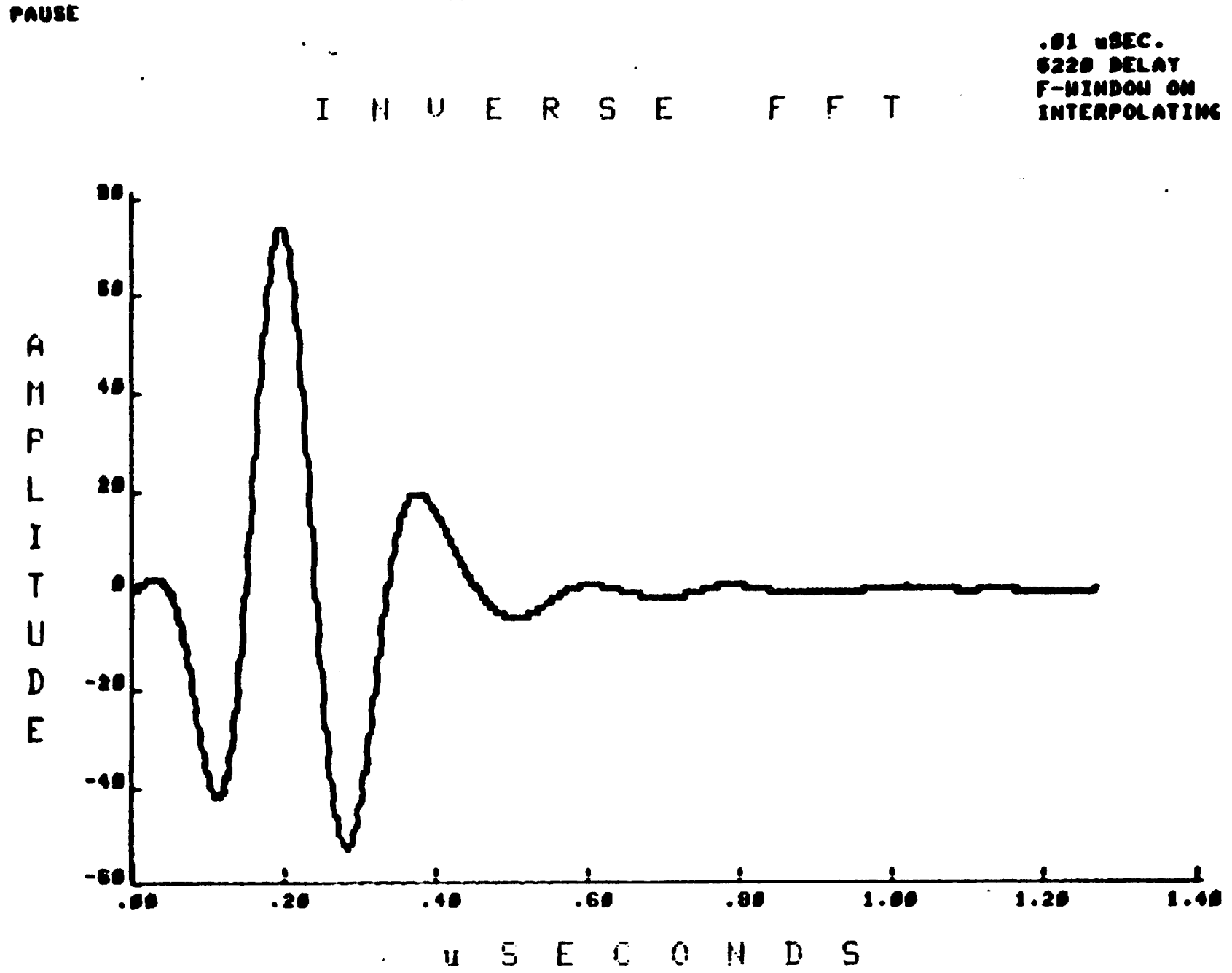

Figure 2-22

EXAMPLE OF THE USE OF WINDOW MODE

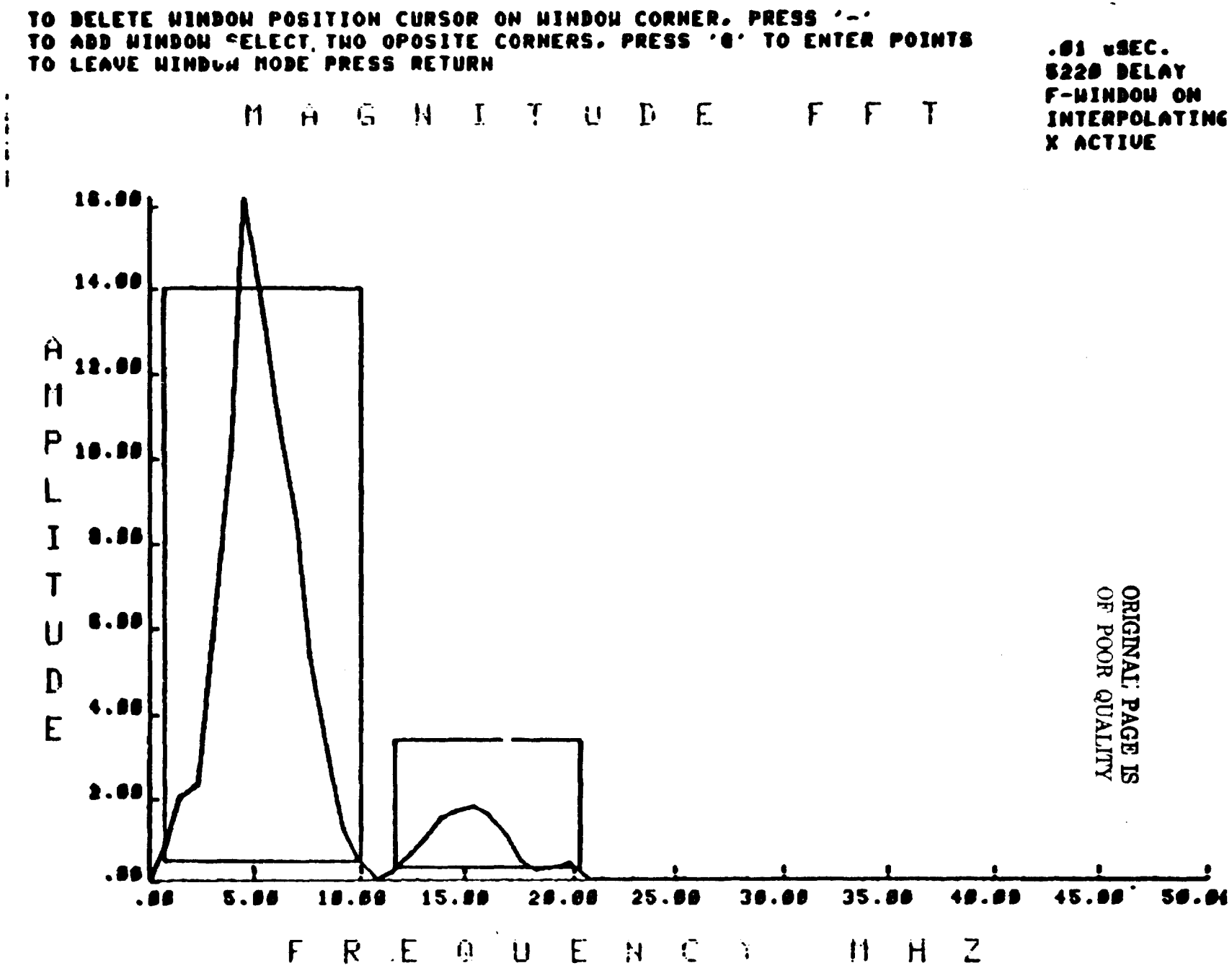

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Figure 2-23

EXAMPLE OF THE USE OF WINDOW MODE

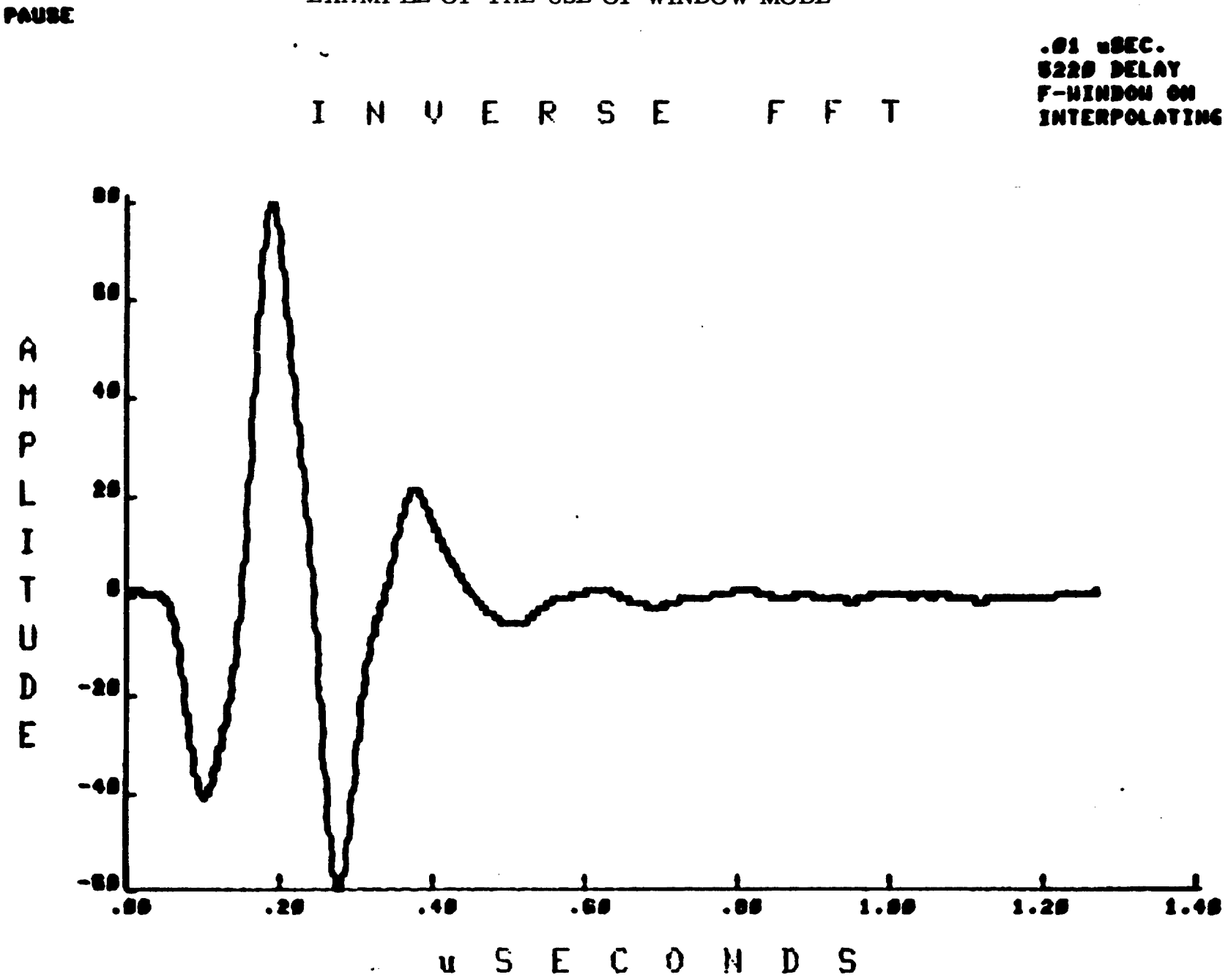
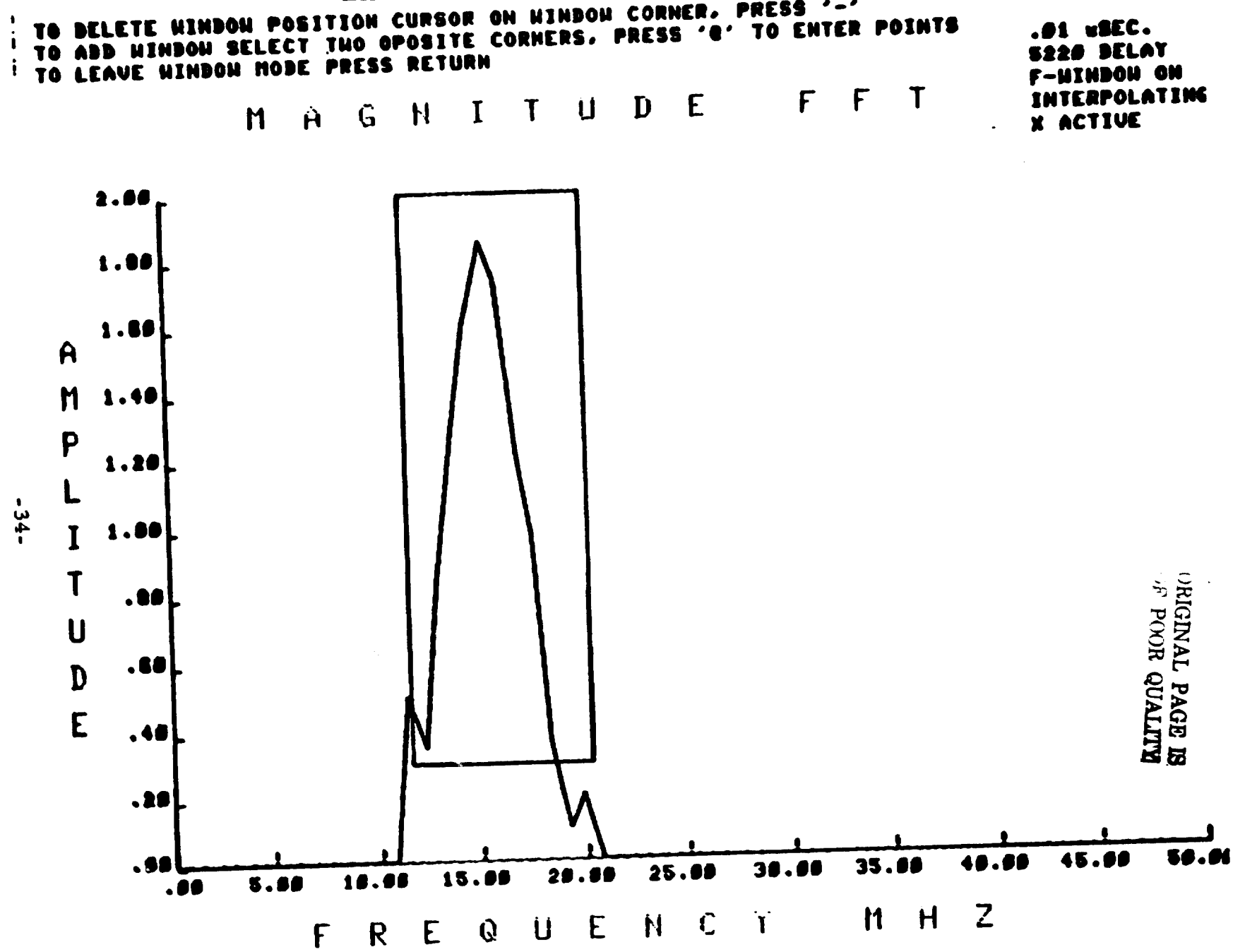


Figure 2-24

EXAMPLE OF THE USE OF WINDOW MODE



ORIGINAL PAGE IS
OF POOR QUALITY

Figure 2-25

EXAMPLE OF THE USE OF WINDOW MODE

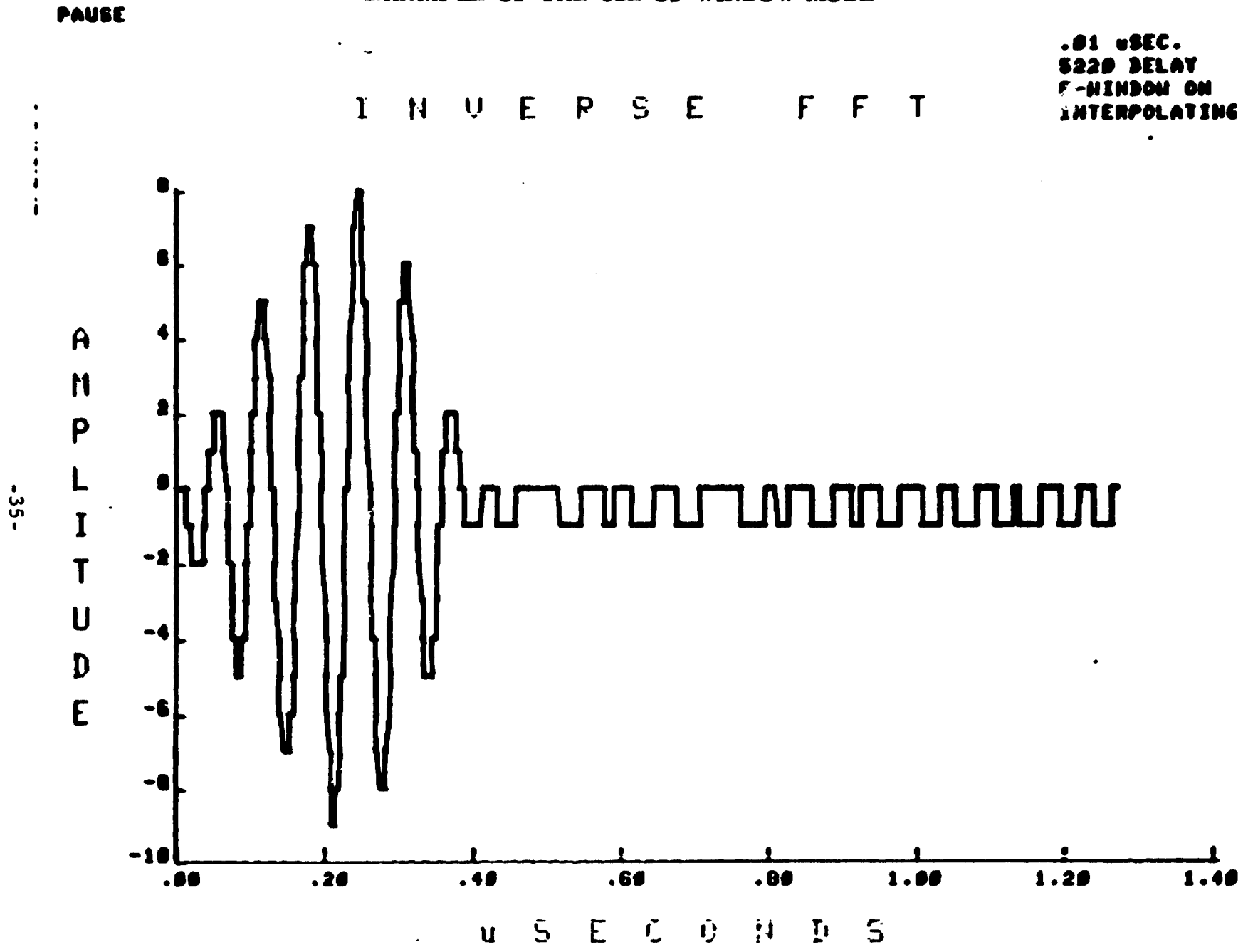


Figure 2-26

APPENDIX

SIMULATED DATA

When SCANNER control is initiated, the operator may select input source = 0 for simulated data. There are three wave forms available for simulated input: sine wave, square wave, and spike. When square or sine waves are selected, the operator is prompted to select waveform frequency using cursor input. The selected wave form is stored in the input buffer and may be processed in the same manner as an input signal.

BIOMATION SET-UP

In the ARM Section select:

Delay = 0
Input
Internal
Channel A
Negative Slope
DC
Level = 0